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AUTHOR Black, Allen
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ABSTRACT

This paper supports the position that Piaget's theory (including both structural and functional components), methods, and empirical data have a central role to play in the development of an effective, comprehensive pedagogy. A structural-developmental theory coordinates the teacher's knowledge of curriculum with knowledge of cognitive demands across subject areas. The Developmental Teacher Education program at the University of California, Berkeley, makes an effort to integrate principles of human development with educational practice, using structural-constructivist orientation as unifying theme. This program is a model for integrating knowledge of developmental psychology and knowledge of subject. There are two components of the program: (1) a two-year, preservice, postgraduate sequence of coursework and supervised teaching, leading to a Master's degree, and (2) two-year inservice for experienced teachers, leading to a Masters degree with a special education option. (LMO)

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# Structural-Developmental Theory and Elementary School Teaching

Allen Black
Graduate School of Education
University of California, Berkeley

TM 850 713

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## Structural-Developmental Theory and Elementary School Teaching

Many educators and educational policy makers hold the view that Piaget's theory has little to offer educational practitioners because it can only prescribe what not to do. In brief, if the child is not developmentally ready to learn a concept, nothing should be done; the teacher should merely wait for development to occur.

Support for this interpretation can be found easily in the developmental literature even among proponents of the theory. Here, Piaget's work is seen as having important implications for educational practice but these implications are not well defined with respect to the requisite knowledge of cognitive development necessary for successful teaching or with respect to specific methods that should be employed. For example, teachers should provide rich settings that will promote development--settings where interactions with materials or peers (constructivism) will facilitate self-generated knowledge (autonomous learning). These general guidelines are fine as far as they go, but it seems to me that they are too wasteful of relevant research.

In contrast, I want to support the position that Piaget's theory (including both structural and functional components), methods, and empirical data have a central role to play in the development of an effective, comprehensive pedagogy. However, for this role to be realized it is necessary for teachers to be active, central figures in linking knowledge of children with knowledge of subject matter --to be genetic epistemologists of a kind and inventors of educational practices.

The most compelling case for this position can be made for

elementary school teachers in the public schools because they are confronted each day with a potentially confusing matrix. On one axis is the broad range of achievement levels represented by their students. On another axis is a broad range of domains of knowledge represented most distinctly by the multiple subjects themselves (e.g. reading, arithmetic, science, and social studies) and at a more refined level by differentiated domains within subject areas (e.g., number, geometry, time). Then, there is a third axis, the more-or-less well defined scope and sequence provided by the school district, state guidelines, and/or text publisher.

For teachers to be able to work effectively within this matrix they need to know more than the subject matter itself. To select and teach lessons while monitoring individual achievement, it is also necessary for teachers to understand the cognitive demands of the curriculum topics within each subject area. Without this knowledge, variation in individual achievement is difficult to interpret and the scope and sequence can come to be seen as arbitrary and remote. Similarly, to provide an integrated curriculum, or to relate individual performance in one area to another area, requires an understanding of similarities and differences in cognitive demands across subject areas. The unique contribution of structural-developmental theory to cognitive psychology and to education is a framework for making these coordinations possible.

To support these claims I will refer to teaching experiences on the part of students in an experimental teacher education program at the University of California, Berkeley, begun in 1979. The Developmental Teacher Education program (Black & Ammon, 1982) is an effort at integrating principles of human development with educational practice

through teacher education.[1] The program is not restricted to applying Piaget's theory to education, but a structural - constructivist orientation is a unifying theme.

The preservice component of the program is a postgraduate, two-year sequence of coursework and supervised teaching that combines a Masters degree with a credential for teaching in preschool through Grade 6. There is also a two-year inservice component for experienced teachers that leads to the Masters degree and, optionally, a special education credential. The Masters degree requirements include a formal thesis.

During the first year of the program both preservice and inservice students take a series of core program seminars on cognitive development (Piaget), language acquisition and moral and social development. Preservice students also take a series of courses that cover curriculum frameworks and methods for teaching elementary school subjects. In the second year, these parallel components are integrated in a second series of seminars concerned with applying cognitive developmental principles to curriculum analysis and development in subject areas (e.g., math, science, reading and writing).

Although the Developmental Teacher Education program is led by faculty in Educational Psychology, faculty from other, more subject oriented divisions within the School of Education are closely involved in teaching courses and guiding thesis research. I mention this because the interdisciplinary approach at the teacher education level, serves as

1. Among the group of educators and psychologists who were most responsible for establishing the Developmental Teacher Education Program, Paul Ammon, Nadine Lambert, and Elliot Turiel are also notable for continuing to make the program work through their individual efforts at linking developmental theory with educational practice.

a model for what is expected of teachers at the classroom level--an integration of knowledge of subjects and methods with knowledge of developmental psychology.

It is through efforts to integrate cognitive developmental theory with mathematics education that I will draw examples that reflect the importance of Piaget's theory for classroom practice. The examples involve the application of theoretical and empirical knowledge of domain distinctions, domain coordinations, and the order of concept acquisition within and between domains to the problem of matching curriculum to the needs of individual students as well as to large scale lesson planning.

Piaget has provided the fundamental genetic epistemological research in many subject areas: e.g., number, space, time, geometry, causality, and chance. The fact that many of these studies focused on the development of concepts unique to specific domains of knowledge is frequently overlooked because scholarly activity has focused on questioning the existence or importance of general stages.

In the classroom, knowledge of the specific steps in concept development within a limited area can be crucial because what appears as inexplicable gaps in children's understandings frequently reflect the failure to make distinctions between conceptual development in different domains of knowledge. For example, it is not intuitively obvious that in the normal course of development an understanding of addition of small numbers precedes and is less complex than an understanding of addition of units of length, and that an understanding of multiplication of numbers precedes and is less complex than an understanding of volume. Although numeric and geometric concepts have common structural properties, one set of concepts can not be reduced to the other.

Between numeric operations and their application to geometric problems, there are some sophisticated geometric concepts that follow their own course of development and need to be mastered in their own right. For example, the lack of strict correspondence between variations in perimeter and variations in area are cognitive developmental issues that should be actively explored in standard textbook series but seldom are. Thus, knowledge of cognitive theory and the empirical data on development within a domain can direct teachers to topics that otherwise might be overlooked.

Piaget also contributed considerable data on across domain coordinations. For example, the child's mastery of number conservation can be considered as a triumph of reversibility within number conception alone (Piaget, 1941/1965). It also can be considered as an achievement based on differentiating a purely numeric concept from spatial concepts (e.g., Piaget, 1941/1965, Chapt. 4). Interestingly, later in development (Piaget et al., 1960, Chapt. 5), an understanding of length requires that it first be differentiated from numeric concepts (so that the number of segments comprising a length do not interfere with its conservation) then integrated (so that units of length can be added or multiplied).

These two examples of how Piaget's studies of development within domains of knowledge are useful to the teacher can also be considered as examples of horizontal décalage. Inhelder (1941/1968) used this term to describe ontogenetic delays in conceptual development. The classic example is the order of acquisition of conservation concepts during middle childhood: first number, then quantity, length, area, weight. This sequence represents increasing structural development within the

concrete operational stage.

In addition to domain distinctions or coordinations, this within stage development can reflect dependencies within a domain of knowledge (e.g., weight needs to be differentiated from quantity) or the presence of cognitive or perceptual factors that make differentiating and coordinating variables in particular problems difficult (e.g., isolating frequency of oscillation of a pendulum from speed and length of arc, Black, 1976.)

I mention this because horizontal décalage is frequently viewed as a weakness in a stage theory. However, in the classroom, an understanding of the structural-developmental bases for décalage also provides a basis for linking the difficulty level of particular concepts or problems with individual differences in achievement.

The task for the teacher then, is to combine knowledge of cognitive development with knowledge of subject matter to produce situations that will promote higher level understanding for each member of the class. The ability to coordinate this knowledge develops in two related areas. One area involves constructing and coordinating classroom activities--instructional methods. I am not concerned with that area here. The second area involves the coordination of cognitive developmental knowledge of the learner with knowledge of the subject matter. This ability occurs at three levels of complexity.

At a first level, knowledge of cognitive development provides an understanding of the orderly progression of concept acquisition, within a particular subject area, that can be applied to individual learning problems. In this situation, the goal is to match a child's given level of understanding of a topic with an appropriate instructional procedure

or to invent one, if necessary. Excellent examples of this kind of activity can be found in the literature on teaching that are published by educators working in the classroom (Davis, 1969; Erlwanger, 1973).[2]

These studies demonstrate that understanding mathematics, can not be reduced to the memorization of a number of explicit algorithms and that the organization of the individual learner's understandings is the central issue. For example, when remediating math problems, principles similar to those that follow, are utilized:

Principle 1. Errors are knowledge and frequently represent overgeneralization of partial knowledge or a lack of integration with other knowledge. (e.g., zero as identity element in addition, null element in multiplication, and place holder in expanded notation).

Principle 2. Do not confront the child with an error and immediately teach the correct algorithm. Rather, probe to reveal what the child understands that is correct as well as incorrect (i.e., use the clinical method).

Principle 3. The child's misunderstanding extends further back in the hierarchy of subject matter knowledge than it first appears. Since children are able to memorize algorithms without understanding and this ability is frequently the source of later difficulties, some bedrock of understanding needs to be found before misconception can be remediated. The general rule is to discover and

2. I am indebted to Jean Stenmark for guiding me to these articles. Ms. Stenmark is currently President, California Mathematics Council - Northern Section and Project Coordinator, EQUALS Project, Lawrence Hall of Science, UC Berkeley.

maintain a balance between computational procedures and conceptual knowledge.

These first three principles reflect an understanding, on the part of the teacher, that knowledge is organized hierarchically—structural development. A fourth and fifth principle are related to the dynamic side of structural-developmental theory—equilibration so I will mention it briefly.

From the equilibration point of view, new knowledge is constructed through an integration of conflicting knowledge (i.e., disequilibrium). Prior to integration, conflicting knowledge held by the learner is not considered contradictory because it is not considered simultaneously. For example, a higher level understanding of enclosed space might follow from integrating the following two incomplete bits of knowledge: (1) the larger the perimeter the larger the area enclosed; and (2) for a given perimeter, the area enclosed can be large or small. Simultaneous coordination of these "facts" by the learner, leads to a cognitive conflict or disequilibrium internal to the learner, that is resolved through a higher level conceptual reorganization.

Principle 4. Disequilibrium that leads to progressive understanding of the material is between conflicting understandings held by the learner. Frequently, disequilibrium that is engendered between the learner's incorrect result using an incorrect procedure and the teacher's or text's correct result using a correct procedure is minimally useful. The information provided is disregarded or assimilated to social or emotional conflict.

Principle 5. Once a new understanding is achieved through the

integration of conflicting understandings, it should be generalized across contents before the next conceptual level is sought. A facility or virtuosity at one level of understanding is necessary for achieving a higher level.

These principles are based on the non-arbitrariness of the acquisition of knowledge. They also run counter to a pedagogy based on the acquisition of facts, computational procedures, and teacher proof curricula.

A second level of complexity is an extension of the first and involves the re-ordering of the sequence of presentation of curriculum topics within a subject area. It requires the application of theory and experience to rethink the scope and sequence proposed by mandated curriculum frameworks, or guidelines provided by curriculum developers. For example, a student teacher was assigned a lesson on angles to be given to a sixth grade class. Apparently because the text writers could assume that the students were already good linear measurers, the concept of angle was introduced via measurement. Protractors were handed out and angles measured. The concepts of similarity, congruence, and equality were then related to measurement. The lesson was unsuccessful, and the supervising teacher noted that this lesson was a problem each year.

The student teacher was reminded that according to developmental theory, a qualitative understanding precedes a quantitative understanding and that angles are strange things. Angles can be equal even though the sides framing them vary greatly in gross size. With this in mind, she re-directed her lesson to first experimenting with congruence and similarity, and <u>then</u> introduced degrees and protractors

as a solution to the problem of how to describe equal angles that vary in size. Her teaching results improved.

It is this kind of analytic and problem solving approach that makes for successful teaching and which, of course, can be carried out on a much larger scale. In theoretical terms the student teacher just mentioned discovered a necessary step in the acquisition of knowledge in one area that also represents a décalage between areas. The text developers had overlooked this distinction and the student teacher invented a solution.

At the third level of complexity, knowledge of the individual learners' achievements across subject areas is utilized. For example, through tutoring a child in the third grade on basic addition and subtraction "facts", a student teacher discovered for herself that although most first graders easily master simple addition problems like: 6 + 4 = ?, many third graders are still having problems solving merely another statement of the same problem: 6 + ? = 10 —the well-known missing addend problem.

The student teacher had been reading The Child's Conception of Number (Piaget, 1941/1965) and was assigned to give a report on the class inclusion problem, so she spontaneously gave it to the child she was tutoring. She was surprised to find that the child also was seemingly unable to perform these part-whole coordinations. Again spontaneously, she looked at the child's written work and found minimal paragraphing skills. Her investigation led to some hypotheses about across domain relationships that she is currently pursuing in the form of a Masters thesis.

Again, the knowledge gained should not be assimilated to a "do-

nothing" interpretation of Piaget's theory. However, the prescription for teaching is not to drill on "number facts" or to memorize a set of paragraphing rules. Rather, it is to move backward in the scope and sequence to concrete composing and decomposing of number families on one hand and to coordinating one or two ideas in written form for purposes of communication on the other. The common element is the coordination of part-whole relationships which can be incorporated into a variety of activities including experience in patterning, ordering, and grouping by similarity and differences.

At this point, I need to make some clarifications. First, intensive clinical intervention by the teacher is only required in the remedial situation. In general, it serves as a model of standard classroom practice only in a limited area of application--as a means for selecting activities and monitoring progress. Nor am I recommending that teachers spend major portions of their time doing clinical assessments of stage development. The examples are meant to indicate that knowledge of stages and the clinical method make it possible to use the curriculum itself as a diagnostic and prescriptive instrument.

In classrooms where a broad range of achievement levels are represented, students who are struggling with concepts at grade level are frequently ready to acquire precursory concepts that they were unable to master a year or two earlier. In this situation, it is important to know what is precursory. The goal is to find or maintain a level of knowledge where constructive activity can be sustained.

Second, I do not mean to imply that the developmentally oriented teacher has to do all curriculum development alone. There are existing instructional programs that are compatible with developmental

principles, although many of their proponents are not aligned directly with Piagetian theory. A common element in these programs is the treatment of the learner as an active constructor of knowledge rather than a memorizer of facts. For example, manipulative based mathematics instruction (e.g., Baratta-Lorton, 1976) is concerned with the child's developing ability to concretely represent mathematical concepts and thereby to understand what underlies paper and pencil manipulations. Hands-on science instruction (e.g., Lowery, 1985) emphasizes science as an action based process, appropriate in some form for children of all ages not merely a collection of facts. Similarly, there are approaches to language learning that view learning to read and to write as integrated, self-regulatory processes that reflect the development of communication skills important to the learner, as well as, to the teacher (Ashton-Warner, 1963; Graves, 1983; Smith, 1978). These approaches are emphasized in our teacher education program and our students have little difficulty assimilating these approaches to a developmental framework.

This conception of the application of structural-developmental theory to education views the teacher at the center of things engaged in on-going cognitive-developmental task analyses. It is necessary for the teacher to be at the center because of the need for matching of curriculum with individual student needs, the lack of cognitive-developmental research in many subject areas, and the lack of available developmentally oriented curriculum. The first of these factors is the most important. The further removed the cognitive psychologist and/or curriculum developer are from individual children the more possibilities arise for utilizing models of learning and related teaching methods that

do not match children's needs.

Taking genetic epistemology seriously does set limits on learning models that can be applied to children in the form of teaching programs, but the implications for teaching practice go far beyond merely waiting for development to occur. As noted, possibilities for effective teaching are opened up through providing a set of organizing principles inherent in all cognitive development which, in turn, provides analytic tools for conducting task analyses of concept attainment within a subject area as well as for coordinating activities relevant to conceptual development across subject areas. However, the examples offered in support of this hypothesis emphasize only the structural side of cognitive developmental theory. For the theory to serve as the basis for developing a comprehensive pedagogy, it is also necessary to link the process (equilibration) side of the theory to specific classroom practices more extensively than has been accomplished to date.

References

Ashton-Warner, S. (1963). Teacher. New York: Simon & Schuster.

Baratta-Lorton, M. (1976). Mathematics their way: An activity centered mathematics program for early childhood education. Menlo Park, CA: Addison Wesley.

Black, A. (1976). Coordination of logical and moral reasoning in adolescence. Unpublished doctoral dissertation, University of California, Berkeley.

Black, A., & Ammon, P. (1982, June). Developmental Teacher Education at Berkeley: Program design and preliminary conclusions. Paper presented at the Jean Piaget Society Annual Symposium, Philadelphia, PA.

Davis, R. B. & Greenstein, R. (1969). Jennifer. New York State Mathematics Teachers Journal, 19 (3), 94-103.

Erlwanger, S. H. (1973). Benny's conception of rules and answers in IPI mathematics. Journal of Children's Mathematical Behavior, 1 (2), 7-26.

Graves, D. (1983). Writing: Teachers and children at work. London: Heineman.

Inhelder, B. (1968). The diagnosis of reasoning in the mentally retarded. (W.B. Stephens et al., Trans.). New York: Chandler. (Original work published 1943).

Lowery, L. (1985). The everyday science sourcebook. San Mateo, CA: Dale Seymour.

Piaget, J. (1965). The child's conception of number. New York: Norton (Original work published 1941).

Piaget, J., Inhelder, B., & Szeminska, A. (1960). The child's conception of geometry. (E. A. Lunzer, Trans.). New York: Basic Books.

Smith, F. (1971). Understanding Reading. New York: Holt, Rinehart & Winston.